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1. SOP 16 Volume Transfer for Glassware – Corrections[1]

The correct formula for calculating the volume at 20 °C in a glass flask is:

$$V_{TD}\ 20\ ^{\circ}C = V_{TDM}\ [1 + (t - 20)(a_s - a_x)]$$

This formula is on the bottom of page 16-4 of the 1986 edition of NBS Handbook 145. If you have questions about the variables, see Handbook 145. The same correction must be applied to the SOP 16 Appendix form for calibration of measuring flasks on page 16-6. The correction to the form is as follows:

$$B = 1 + A \quad \text{where A } = (t - 20)(a_s - a_x)$$

In the 1996 draft SOPs that were presented in San Antonio or the recording forms that may be included in Basic seminar materials, the correction must be made as follows (for both the text and the Appendix form):

$$V_{TD}\ 20\ ^{\circ}C = V_{TDM}\ [1 + (t - 20)(a - b)]$$

Impact of SOP 16 Error

The impact of this error (subtraction sign instead of addition) in the ranges shown in the following tables is less than the reported uncertainties and much less than the Handbook 105-2 tolerances. Although, it appears unlikely to be a problem, laboratory calibrations of glassware should be investigated and corrective action applied if needed. If gravimetric testing was performed on glassware, proper temperature corrections are in Handbook 145, and this error/impact is not a concern.

Impact (in mL) based on formula correction at the following temperatures/volumes									Range of Uncertainties[2]	
V(TDM)	15.0 °C	18.0 °C	19.5 °C	20.0 °C	20.5 °C	22.0 °C	25.0 °C	Tolerance	Low	High
50 mL	-0.00750	-0.00300	-0.00075	0	0.00075	0.00300	0.00750	0.3		
100 mL	-0.01500	-0.00600	-0.00150	0	0.00150	0.00600	0.01500	0.2		
½ pint	-0.03549	-0.01420	-0.00355	0	0.00355	0.01420	0.03549	0.3	0.040	0.237
1 pint	-0.07098	-0.02839	-0.00710	0	0.00710	0.02839	0.07098	0.4		
1 quart	-0.14195	-0.05678	-0.01420	0	0.01420	0.05678	0.14195	0.7		
1 gallon	-0.56781	-0.22712	-0.05678	0	0.05678	0.22712	0.56781	1.2		
Impact (in minims) based on formula correction at the following temperatures/volumes									Range of Uncertainties*	
V(TDM)	15.0 °C	18.0 °C	19.0 °C	20.0 °C	20.5 °C	22.0 °C	25.0 °C	Tolerance	Low	High
50 mL	-0.12173	-0.04869	-0.01217	0	0.01217	0.04869	0.12173	4.87		
100 mL	-0.24346	-0.09738	-0.02435	0	0.02435	0.09738	0.24346	3.25		
1/2 pint	-0.57600	-0.23040	-0.05760	0	0.05760	0.23040	0.57600	4.87	0.354	3.840
1 pint	-1.15200	-0.46080	-0.11520	0	0.11520	0.46080	1.15200	6.49		
1 quart	-2.30400	-0.92160	-0.23040	0	0.23040	0.92160	2.30400	11.36		
1 gallon	-9.21600	-3.68640	-0.92160	0	0.92160	3.68640	9.21600	19.48		

[1] Thanks to Joe Rothleder for discovering this error during the course of the analysis of the 1997 WRAP "½-pint round robin". The correct formula has been verified by Dr. Vern Bean (NIST, Volume) and Henry Oppermann (NIST Office of Standards Services).

[2] *The range of uncertainties is from data reported in regional round robins for WRAP '97/98 and for SEMAP '97/98.

2. Reference Temperatures for Volume Calibrations

Review of recent round robins indicates a need to review reference temperatures used in volume calibrations. Regardless of which SOP calibration procedure is used, the correct temperature correction should be applied. If you use a gravimetric procedure that was originally designed for glassware (e.g., SOP 14) when testing a field test measure, you will need to use the appropriate temperature correction. Additionally, the cubical coefficient of expansion MUST be in the same reference units of "per degree". For example, if a test measure is made of stainless steel and will be referenced to 60 °F, the cubical coefficient of expansion value is 2.65 x 10-5 /°F. The units given in Table 9.10 in Handbook 145 should simply be "/°C" rather than "cm/°C" and "cm3/°C". When the correct coefficient of expansion value is multiplied by the temperature difference, the units cancel, resulting in a correction factor for the volume units.

Measurement parameter	Reference temperature
Petroleum products: 5-gallon test measures; large volume provers	Internationally: 15 °C 15.55 °C (60 °F)
Food products that must be kept refrigerated: e.g., large volume provers used for milk	4.44 °C (40 °F)
All general-purpose glassware; Food products sold unchilled such as sodas or wine	20 °C (68 °F)
Frozen food labeled by volume	0 °C (17.8 °F)
Beer	3.9 °C (39.1 °F)

3. Lab Wizard Stalls – Numerical Processor

We have had problems with a few laptop computers stalling with the Lab Wizard software. During the last advanced class, Steven Herzog (Wyle) had experience with other C++ programs doing this same thing (apparently there's a conflict with the C++ processor and the internal processor). He helped us straighten out all of the machines here at the time that wouldn't work. Here's how to make this fix:

Go to:
1. My Computer
2. Control Panel
3. System
4. Click on the Device Manager Tab
5. Go to the "System Devices" and click on the "+" to open that directory
6. Click on Numeric Data Processor and then Properties
7. Then click on the "Settings" tab
8. Then select "Never use the numeric data processor"
9. Then select "ok" all the way out and it should prompt you to restart your computer.

We have not found this "fix" to bother anything else on the machines. Please let me know if you had this problem, if it fixes the stalls for you and if there are any other side effects.

4. Mass Code Uncertainties

U(s) for Starting Restraints

At the last Advanced Mass seminar, Zeina Jabbour (Mass Group), Carroll Croarkin (Statistical Engineering Division) and Georgia Harris (OWM) discussed the routine practices in place for combining uncertainties for starting restraints when using the mass code. Previous instructions indicated that the 1-sigma values for each standard are to be combined in a root sum square and entered into the mass code as the "systematic error" for the starting restraint as per the following equation.

$s_r = \sqrt{u_{s1}^2 + u_{s2}^2}$ previously recommended

This is no longer the case. These 1-sigma values should simply be added unless the two standards (or group of standards) were calibrated together *and* a combined uncertainty is available in your calibration report. This change is consistent with the Mass Group practice and with how the current mass code distributes the uncertainties to each of the unknown weights being compared.

$s_r = u_{s1} + u_{s2}$ currently recommended

This change will increase the reported uncertainties for your subsequent calibrations. You will need to evaluate the impact of this change for your measurement process. In those cases, where you have very small standard deviations of the process, this change will be more significant. Two examples follow.

Case 1.

Two 1-kg standards, each with a reported uncertainty of 0.05 mg (k=2) will have a 1-sigma standard uncertainty of 0.025 mg each. Combining them by root sum square using the old equation, you would have entered 0.03535 mg as the standard uncertainty of your starting restraint (entered as "systematic error"). By adding them, you will enter 0.050 mg as the standard uncertainty of your starting restraint (entered as "systematic error"). If you have a standard deviation of your process of 0.075 mg, the combined uncertainty will be 0.0829 mg (k=1) or 0.17 mg (k=2) using the former method of combining the standard uncertainties for the starting restraints. Using the current formula, it will be 0.090 mg (k=1) or 0.18 mg (k=2). In this case, the difference is 0.01 mg (or about 6% of the reported uncertainty). This example does not include the between-time standard deviation or any other sources of standard uncertainties.

Case 2.

Using the same scenario as is case 1 and substituting a standard deviation of your process of 0.035 mg, the combined uncertainty will be 0.0497 mg (k=1) or 0.09949 mg (k=2) using the former method of combining the standard uncertainties for the starting restraints. Using the current formula, it will be 0.061 mg (k=1) or 0.122 mg (k=2). In this case, the difference is 0.0225 mg (or about 23% of the reported uncertainty).

	Old formula	New formula
Case 1.		
U(s) = 0.05 mg (k=2 for 2 standards)	U(s) = 0.03535 mg U (k=2) = 0.17 mg	U(s) = 0.050 mg U (k=2) = 0.18 mg
S(p) = 0.075 mg		
Case 2.		
U(s) = 0.05 mg (k=2 for 2 standards)	U(s) = 0.03535 mg U (k=2) = 0.09949 mg	U(s) = 0.050 mg U (k=2) = 0.122 mg
S(p) = 0.035 mg		

NIST IR 5672 S(b) Equation Correction

The correct equation for the between-time standard deviation for the 5-1 design (Tech Note 952 design: A.1.4) with standards in positions 1 and 2 (two-weight restraint) and the check standard either the difference between positions 1 and 2 or as used in position 4 follows. The 2/3 multiplier was not included in IR 5672.

$$\text{5-1 design: } s_b^2 = \frac{2}{3}\left(s_t^2 - \frac{3}{10}s_w^2\right)$$

5. CIPM Air Density Formula

For all precision work, State laboratories should begin using the CIPM 1981/91 formula for the calculation of air density. The CIPM formula is already used in the NIST Mass Code and in the Lab Wizard software. The difference between this formula and the one presented in NBS Handbook 145, SOP 2 is less than one-tenth of the uncertainty in the air density equation. However, this change is being made for international uniformity in anticipation of the key comparisons project for mass calibrations during 2000. Once the change has been made and verified in computer programs, it should be transparent to the user. Handbook 145 will likely retain both formulas in the future since the current formula is easier to handle when performing manual calculations with a calculator.

A copy of the paper[3] is attached to the mailed copy of this Tech Memo and contains the formulae required for calculation. The following data set is given in Metrologia 1992, 29, p 67-70 (p. 69), as calculated in Excel 97:

Air Density Calcs			TN 577	HB 145	CIPM 1981/91
P (mm Hg) conversion from Pa	Temp (C)	RH (%)	mg/cm^3	mg/cm^3	mg/cm^3
750.061505	20	50.00	1.18601696	1.18346328	1.18347171
825.067656	20	10	1.30919572	1.30655695	1.30658174
750.061505	15	90	1.20639233	1.20231326	1.20240788
450.036903	25	50.00	0.69556372	0.69425220	0.69416182

Two Excel spreadsheets are available for downloading from the NIST Internet site:

Air (CIPM).xls contains the equations for the CIPM formula, SOP 2, and the older formula contained in NBS Technical Note 577 which was used prior to the publication of Handbook 145 in 1986. This spreadsheet contains several graphs showing the impact of this change.

Air Density for Lab Wiz 2 (CIPM).xls contains the pages for automating data collection with Lab Wizard 2 (downloadable from the www.tyrad.com site) for electronic devices once a virtual laboratory file is set up. This spreadsheet uses the CIPM formula only and documents the constants used. No training is being provided for Lab Wizard 2 at this time.

[3] Davis, R. S., Equation for the Determination of the Density of Moist Air (1981/91), Metrologia, 1992, 29, 67-70.